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<p>(54) Title: CHANNEL SELECTION IN A CELLULAR COMMUNICATION SYSTEM</p> <div style="text-align: center; margin-top: 20px;"> <p>The diagram shows seven rows of frequency sequences, each with 20 elements in boxes. The rows are labeled C₁₁, C₂₁, C₃₁, C₄₁, C₅₁, C₆₁, and C₇₁ on the left. Arrows labeled 42 and 43 point to specific elements in the sequences.</p> <table border="1" style="margin: auto; border-collapse: collapse;"> <tr> <td>C₁₁</td> <td>1</td><td>2</td><td>3</td><td>6</td><td>9</td><td>12</td><td>15</td><td>18</td><td>21</td><td>5</td><td>8</td><td>11</td><td>14</td><td>17</td><td>20</td><td>4</td><td>7</td><td>10</td><td>13</td><td>16</td><td>19</td> </tr> <tr> <td>C₂₁</td> <td>4</td><td>5</td><td>6</td><td>9</td><td>12</td><td>15</td><td>18</td><td>21</td><td>3</td><td>8</td><td>11</td><td>14</td><td>17</td><td>20</td><td>2</td><td>7</td><td>10</td><td>13</td><td>16</td><td>19</td><td>1</td> </tr> <tr> <td>C₃₁</td> <td>7</td><td>8</td><td>9</td><td>12</td><td>15</td><td>18</td><td>21</td><td>3</td><td>6</td><td>11</td><td>14</td><td>17</td><td>20</td><td>2</td><td>5</td><td>10</td><td>13</td><td>16</td><td>19</td><td>1</td><td>4</td> </tr> <tr> <td>C₄₁</td> <td>10</td><td>11</td><td>12</td><td>15</td><td>18</td><td>21</td><td>3</td><td>6</td><td>9</td><td>14</td><td>17</td><td>20</td><td>2</td><td>5</td><td>8</td><td>13</td><td>16</td><td>19</td><td>1</td><td>4</td><td>7</td> </tr> <tr> <td>C₅₁</td> <td>13</td><td>14</td><td>15</td><td>18</td><td>21</td><td>3</td><td>6</td><td>9</td><td>12</td><td>17</td><td>20</td><td>2</td><td>5</td><td>8</td><td>11</td><td>16</td><td>19</td><td>1</td><td>4</td><td>7</td><td>10</td> </tr> <tr> <td>C₆₁</td> <td>16</td><td>17</td><td>18</td><td>21</td><td>3</td><td>6</td><td>9</td><td>12</td><td>15</td><td>20</td><td>2</td><td>5</td><td>8</td><td>11</td><td>14</td><td>19</td><td>1</td><td>4</td><td>7</td><td>10</td><td>13</td> </tr> <tr> <td>C₇₁</td> <td>19</td><td>20</td><td>21</td><td>3</td><td>6</td><td>9</td><td>12</td><td>15</td><td>18</td><td>2</td><td>5</td><td>8</td><td>11</td><td>14</td><td>17</td><td>1</td><td>4</td><td>7</td><td>10</td><td>13</td><td>16</td> </tr> </table> </div>			C ₁₁	1	2	3	6	9	12	15	18	21	5	8	11	14	17	20	4	7	10	13	16	19	C ₂₁	4	5	6	9	12	15	18	21	3	8	11	14	17	20	2	7	10	13	16	19	1	C ₃₁	7	8	9	12	15	18	21	3	6	11	14	17	20	2	5	10	13	16	19	1	4	C ₄₁	10	11	12	15	18	21	3	6	9	14	17	20	2	5	8	13	16	19	1	4	7	C ₅₁	13	14	15	18	21	3	6	9	12	17	20	2	5	8	11	16	19	1	4	7	10	C ₆₁	16	17	18	21	3	6	9	12	15	20	2	5	8	11	14	19	1	4	7	10	13	C ₇₁	19	20	21	3	6	9	12	15	18	2	5	8	11	14	17	1	4	7	10	13	16
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<p>(57) Abstract</p> <p>A method in a cellular communication system provides selection of a channel for use in a pending communications operation, the selection reducing the likelihood of co-channel interference. In each co-channel cell, frequencies from the cell's frequency group are ordered in a sequence. A different frequency in each cell is designated as having a highest priority. Successively lower priorities are then assigned, in each cell, to remaining frequencies in sequence. Then, in each cell, selection is made by identifying the available frequency having the highest priority. The method may be modified to provide for even distribution of hardware use by changing the priorities in each cell periodically. The method may also be modified for use in a fully synchronized time division multiple access (TDMA) system by performing the above steps with respect to channels instead of frequencies. The method may further be modified for use in a pseudo-synchronized TDMA system (i.e., one in which the TDMA time slots of one cell are slowly shifting with respect to the time slots of another cell) by selecting, instead of the highest priority channel, one having a lower priority based on a time difference between corresponding time slots in two co-channel cells.</p>																																																																																																																																																												

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CHANNEL SELECTION IN A CELLULAR COMMUNICATION SYSTEM**BACKGROUND**

The invention relates to channel selection in a mobile radio communication system, and more particularly to methods and apparatuses for selecting a channel to be used in a mobile radio communication system cell, the selection being made in a way that reduces the occurrence of co-channel interference.

In a cellular mobile radio communication system, the geographic area served by the system is divided into geographically defined cells, each of which is serviced by a base station. In the system, there is a finite number of carrier frequencies that are available for use during communications. A frequency group, consisting of a subset of all of the available frequencies, is assigned to each cell for that cell's use during communications. However, because the number of frequency groups is limited, it is necessary to reuse them within the area served by the system. Because the use of a particular frequency by two different cells can result in co-channel interference, possibly reducing the carrier-to-interference ratio below an acceptable quality threshold, an attempt is made to assign frequency groups to cells in a manner that results in any given cell using a different frequency group from its neighbors. A group of cells is called a cluster when the combination of their individually assigned frequency groups includes all available frequencies assigned to the system. There are usually a number of clusters within a system, each repeating a particular frequency allocation, called a reuse pattern.

Cells to which the same frequency group has been allocated are called co-channel cells. It follows from this description that each co-channel cell is assigned to a different cluster from all other co-channel cells.

It is desirable to try to limit the effect of co-channel interference which arises from the simultaneous use of a particular frequency by two different co-channel cells. This can be achieved by assigning frequencies so that the distance
5 between co-channel cells is maximized. However, maximizing this distance means assigning fewer frequencies to each cell. This may conflict with system requirements to increase the capacity of each cell by increasing the number of frequencies assigned thereto.

10 In a normal reuse pattern, such as the 21-cell frequency repeat pattern, the average expected co-channel interference in a given cell is based on the assumption that all co-channel frequencies in all co-channel cells are used. That is, for a cell having a frequency group f_A containing frequencies f_1 ,
15 f_{22} , f_{43} , f_{64} , . . . , the average expected co-channel interference in a given cell is calculated by assuming that each of the cell's frequencies are simultaneously in use by the cell and by the co-channel cells (i.e., those cells to which the same frequency group has been assigned), even though this is
20 often not the case.

For example, reference is made to Figure 1, which shows a system having a 7-cell frequency repeat pattern. Two cell clusters, each consisting of seven cells, are shown. The first cell cluster 100, consists of cells labeled C_{11} , C_{12} , C_{13} ,
25 C_{14} , C_{15} , C_{16} , and C_{17} . The second cell cluster 102 consists of cells labeled C_{21} , C_{22} , C_{23} , C_{24} , C_{25} , C_{26} , and C_{27} . The showing of only two cell clusters is done here solely for convenience. It should be understood that, in practice, a mobile telephone system may have more than two cell clusters. It should also
30 be understood that the following discussion is not limited to systems having a 7-cell frequency repeat pattern, but is equally applicable to all repeat patterns, including the popular 12-cell and 21-cell frequency repeat patterns.

As shown in Figure 1, each cell is assigned a frequency group, denoted here as the letter "f" with a letter subscript. For example, each of cells C_{11} and C_{21} has been assigned the frequency group f_A .

- 5 Specific frequencies are denoted here as the letter f with a numeric subscript. In the 7-cell frequency repeat pattern shown in Figure 1, frequency group f_A consists of the frequencies $f_1, f_8, f_{15}, f_{22} \dots$, frequency group f_B consists of the frequencies $f_2, f_9, f_{16}, f_{23} \dots$, and so on.
- 10 A mobile station, M, in cell C_{11} operates on one of the frequencies in group f_A , such as f_{22} . The call may or may not experience co-channel interference from another user located in cell C_{21} , depending on whether the same frequency, in this case f_{22} , is being utilized in cell C_{21} .
- 15 In high traffic, typically 70 - 80% of the traffic frequencies, or channels, are in use. If traffic utilization rises higher than 80%, the user's perceived congestion becomes intolerable. It follows that, in high traffic, the probability that a particular channel is simultaneously being used
- 20 in both cells C_{11} and C_{21} is high. This simultaneous use results in a high expected co-channel interference.

Referring now to Figure 2, the middle cell C_{11} , first shown in Figure 1, is illustrated along with its six closest co-channel cells, $C_{21}, C_{31}, C_{41}, C_{51}, C_{61}$, and C_{71} . It should be understood

25 that each of the illustrated co-channel cells is located at the center of a seven-cell cluster, similar to the first cell cluster 100. However, for simplicity, the remaining cells from each cluster, which are located between those shown, are not illustrated.

- 30 As previously stated, each co-channel cell has been assigned the same frequency group. For the sake of convenience in the

remainder of this discussion, references made to particular frequencies within a frequency group will assume that the frequencies within the group are numbered sequentially, from 1 to n, where n is an integer. It will also be understood that
5 each particular frequency receives the same numbering assignment in each co-channel cell.

Figure 3 illustrates a method for assigning an available frequency for use within a cell. For the purpose of example, a frequency group 300 is shown which has twenty-one sequentially numbered frequencies. As shown by the arrow 302,
10 frequencies are assigned by taking the leftmost frequency that is available in the list. That is, priority assignments have been made to each of the frequencies, such that priority of selection increases the closer to the left a given frequency
15 is in the list. Consequently, frequency 1 is first investigated to see whether it is available/suitable. If it is not, the search continues to frequency 2, and so on, until an available/suitable frequency is found. If no frequency is found, congestion arises.

20 In the method described above with reference to Figure 3, if all cells have the same list and the same algorithm for selecting frequencies, then frequency 1 will often be used and frequency 21 will almost never be used. Consequently, the co-channel interference conditions on frequency 1 will
25 generally be as poor or good as the system is designed for, and frequency 21 will often provide good co-channel interference values in the rare instances in which it is assigned for use by a cell. Thus, even when each cell experiences low traffic, the co-channel interference experienced by the few
30 assigned frequencies will still be high, since the same frequencies are likely to be assigned by each cell.

The reader will recognize that the deficiencies in the method just described are present when each frequency is assigned to

only one channel in a system called Frequency Division Multiple Access (FDMA), and also when each frequency is assigned to more than one channel, in a Time Division Multiple Access (TDMA) system.

- 5 Therefore, it is an object of the present invention to select frequencies for use in co-channel cells in an FDMA mobile communication system in such a manner that the quality of a connection (as measured by the amount of co-channel interference on a frequency) is improved when the traffic level is
10 less than a maximum capacity.

Another object of the invention is to select frequencies for use in co-channel cells in such a manner that the cell hardware associated with a particular frequency is not unevenly used, relative to the cell hardware associated with
15 other frequencies in the cell.

A further object of the invention is to select frequencies for use in co-channel cells operating in a synchronized TDMA environment in such a manner that the quality of a connection is improved when the traffic level is less than a maximum
20 capacity.

A still further object of the invention is to select channels for use in co-channel cells operating in a synchronized TDMA environment in such a manner that the quality of a connection is improved when the traffic level is less than a maximum
25 capacity.

Yet another object of the invention is to select channels for use in co-channel cells operating in a TDMA environment in an asynchronous state wherein the TDMA structures of co-channel cells are sliding slowly relative to each other and the time
30 differences are known. This state is referred to hereafter as

a pseudo-synchronized TDMA environment or simply pseudo-synchronization.

SUMMARY OF THE INVENTION

According to the present invention, the foregoing and other
5 objects are attained by allocating frequency use in a manner that takes advantage of lower average frequency use during periods of lower traffic, such as in off-peak hours.

In accordance with an exemplary FDMA embodiment of the invention, a frequency is selected for use in a pending
10 communications operation by first forming a sequence of frequencies that is the same in all co-channel cells. Next, for each cell, one frequency in the sequence of frequencies is designated to have a highest priority, the designated frequency being different in at least two cells. Then, for each
15 cell, progressively lower priorities are assigned to remaining frequencies by beginning the assigning with a next frequency that follows the designated frequency in the sequence, and continuing to assign in sequence through the list until each of the different frequencies has been assigned
20 a priority. Alternately, the sequence of frequencies in each co-channel cell can be different and arranged in a manner so that the highest priority channels in one co-channel cell are of a relatively low priority in the other co-channel cells. Thus, in each cell, a frequency is selected for use in the
25 pending communications operation by choosing, from the sequence of frequencies, an available frequency having a higher priority than all other available frequencies in the sequence of frequencies.

In accordance with another embodiment of the invention, the
30 above-described steps of, for each cell, designating and assigning are performed periodically, so that the same

frequency with the same priority is not designated twice in succession.

In yet another embodiment of the invention, the above-described step of designating is further based on knowledge of
5 current frequency use in the system.

According to another embodiment of the present invention, the sequence of frequencies in the co-channel cells is not the same, but is instead varied based upon the priority usage of frequencies in other co-channel cells. The frequency plan for
10 each co-channel cell can be based on descendingly ranked priority channels for that co-channel cell, followed by channels which are used as priority channels in other co-channel cells listed in an ascending manner.

In still another embodiment, the invention is utilized in a
15 fully synchronized time division multiple access (TDMA) system by forming a sequence of channels that is the same in all co-channel cells. Then, for each cell, one channel in the sequence of channels is designated to have a highest priority, the designated channel being different in at least two cells.
20 Then, for each cell, progressively lower priorities are assigned to remaining channels by beginning the assigning with a next channel that follows the designated channel in the sequence, and continuing to assign in sequence through the list until each of the different channels has been assigned a
25 priority. Finally, in each cell, a channel is selected for use in the pending communications operation by choosing, from the sequence of channels, an unselected channel having a higher priority than all other unselected channels in the sequence of channels.

30 In yet another embodiment, the invention is adapted for use in a cellular communication system operating in accordance with a pseudo-synchronized time division multiple access (TDMA)

system in which a time difference between channels is known, by forming a sequence of channels that is the same in all cells. Then, for each cell, one channel in the sequence of channels is designated to have a highest priority, the designated channel being different in at least two cells. 5 Next, progressively lower priorities are assigned to remaining channels in each cell by beginning the assigning with a next channel that follows the designated channel in the sequence, and continuing to assign in sequence through the 10 list until each of the different channels has been assigned a priority. Then, in each cell, a first unselected channel is identified from the sequence of channels. The first unselected channel has a higher priority than all other unselected channels in the sequence of channels. Finally, an 15 unselected channel is selected for use in the pending communications operation in each cell by selecting a channel having a priority that is alternatively equal to or less than the priority of the first unselected channel in response to a determination that the time difference is greater than a 20 predetermined amount.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing objects and features of the present invention will be more readily appreciated upon reading the following detailed description, when read in conjunction with the 25 Figures in which:

Figure 1 is a diagram of part of a cellular telephone system utilizing a 7-cell frequency repeat pattern;

Figure 2 is a diagram showing a middle cell from a 7-cell cluster, and its six closest co-channel cells;

30 Figure 3 shows a related method of allocating frequencies in co-channel cells;

Figure 4(a) illustrates frequency allocation in seven co-channel cells in an FDMA system in accordance with one exemplary embodiment of the invention;

Figure 4(b) illustrates frequency allocation in seven
5 co-channel cells in an FDMA system in accordance with another exemplary embodiment of the invention;

Figure 5 shows co-channel interference between two cells in a fully synchronized TDMA system;

Figure 6 shows a priority list for use in a three cell fully
10 synchronized TDMA system, in accordance with another exemplary embodiment of the invention;

Figure 7 shows co-channel interference between two cells in a pseudo-synchronized TDMA system;

Figure 8 illustrates channel allocation in accordance with
15 another exemplary embodiment of the invention to be used in a pseudo-synchronized TDMA system; and

Figure 9 illustrates another exemplary embodiment of the invention which evenly distributes the allocation of frequency usage in a cell.

20 DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to Figure 4(a), a method in accordance with an exemplary embodiment of the present invention is shown. The arrow 402 indicates that selection of frequency is made by taking the leftmost frequency being available in the list.
25 That is, each frequency has been assigned a priority such that a given frequency's priority of selection increases the closer to the left that frequency is in the list. Consequently, for cell C_{11} , the selection order 404 requires that frequency 1 be

investigated first to determine whether it is available and suitable for use. If it is not, then frequency 2 is investigated, and so on, until a frequency is found that is both available and suitable for use.

5 This method differs from the conventional method that was described with reference to Figure 3, in that the selection orders for each of the co-channel cells are no longer identical to one another. Instead, priorities have been assigned in each cell so that, for example, the selection order 404
10 corresponding to cell C_{11} is the sequence 1, 2, 3, . . . 20, 21; the selection order 406 corresponding to cell C_{21} is the sequence 4, 5, 6, . . . 21, 1, 2, 3; the selection order 408 corresponding to cell C_{31} is the sequence 7, 8, 9, . . . 21, 1, 2, 3, 4, 5, 6; and so forth for the remaining cells having
15 selection orders 410, 412, 414, and 416, as shown in Figure 4(a). The result is that the frequency that is designated to be investigated first is different for each of the co-channel cells.

The number of frequencies by which each first frequency
20 differs from co-channel cell to co-channel cell is one less than the number of frequencies that would have to be in use in a given cell before any particular frequency can be in use in more than one cell, assuming equal load on all co-channel cells. In the embodiment shown in Figure 4(a), this offset
25 has been set to 3, but it will be recognized by those skilled in the art that the offset could be set differently to optimize performance in a particular system.

Thus, in the embodiment shown in Figure 4(a), if each cell carries no more than three calls, then none of the frequencies
30 will be used more than once. This situation corresponds to very low traffic. The more traffic there is, the more frequencies which are used more than once.

The situation in which no cell carries more than three calls is not very likely. A more realistic case is illustrated with the thick vertical line 418 which indicates an average usage of three channels per cell, but with a varying load level per
5 cell. In this case, the frequency corresponding to frequency 7 and frequency 16 are used twice, frequency 9 and frequency 12 are unused, and the remaining frequencies are used only once.

Thus, in accordance with this embodiment of the invention, the
10 load would have to approach the maximum of twenty-one channels before co-channel interference would reach the same high values that were obtained using the conventional method previously described with reference to Figure 3 at low traffic load levels.

15 According to another exemplary embodiment, illustrated in Figure 4(b), those channels which are assigned to the right of the "priority" channels are assigned in ascending order of their respective priority usage in the channel assignments of other co-channel cells. Thus, for example, in cell C_1 , channel
20 6 is given the fourth highest priority, as compared with channel 4 in the exemplary embodiment of Figure 4(a), because channel 6 has the third highest priority assignment in cell C_{21} .

Accordingly, the sequence 6, 9, 12, 15, 18, and 21 of channel
25 sequence 420 in cell C_1 , corresponds to those channels which have the third highest priority in the other co-channel cells. The ascending order continues with those channels having second highest priority (i.e., 5, 8, 11, 14, 17, and 20), followed by those channels having the highest priority (i.e.,
30 4, 7, 10, 13, 16, and 19) in the other co-channel cells. In this way, co-channel interference will be reduced during lower than maximum capacity usage periods since the channels designated as being of a high priority for one co-channel cell

(e.g., channels 1 and 2 in cell C_{11}) have relatively low priority in the channel assignment sequences of the other co-channel cells, for example channel assignment sequences 422-432.

- 5 Those skilled in the art will appreciate that although the channel assignments have been illustrated in Figure 4(b) as following cell order, i.e., in cell C_{11} the sequence 5, 8, 11, 14, 17, and 20 corresponds to the third highest priority channel assignment in cells C_{21} , C_{31} , C_{41} , C_{51} , C_{61} and C_{71} ,
10 respectively, that any desired order can be used as long as the channels are assigned in ascending priority order. Thus, in the exemplary embodiment of Figure 4(b), the order of the channels ranked 4th through 21st in priority can be changed as long as those channels having third highest priority in other
15 co-channel cells have a higher priority than those channels having a second highest priority in other co-channels cells, which in turn have a higher priority than those channels having a highest priority in other co-channel cells.

- Moreover, if more than one co-channel cells are served by the
20 same MSC, then the system will know which channels are used for traffic in each of these co-channel cells. This knowledge can be used to further reduce co-channel interference. Suppose, for example, that cells C_{31} and C_{41} are served by the same MSC and channel assignments are made according to the
25 channel assignment scheme shown in Figure 4(b). Further, suppose that channels 12 and 15 are currently being used for traffic in cell C_{41} and channels 7, 8, and 9 are currently being used for traffic in cell C_{31} . If another call is to be established in cell C_{31} , the next channel in the list is 15.
30 However, since the system knows that channel 15 is already in use in cell C_{41} , channel 18 will be allocated to the new call instead of channel 15 to reduce the likelihood of co-channel interference. This knowledge of co-channel usage can be used

in any of the above-described embodiments whenever such knowledge is available.

The description has, so far, taken the case where each carrier frequency has a single channel assigned to it. Such a system
5 is referred to as a Frequency Division Multiple Access (FDMA) system. Another feature of the present invention is that the improvement described above is still present if one carrier frequency is assigned to carry more than one conversation, such as in a Time Division Multiple Access (TDMA) system,
10 which defines each communication channel as one or more time slots on a particular carrier frequency.

For example, if each carrier frequency is divided into three time slots, then only one carrier is used for every three conversations in each cell. This situation is illustrated in
15 Figure 5. The three time slots 506 defined by the TDMA system are sequentially repeated over time, as shown. Figure 5 depicts the situation in which cell 1's carrier frequency 502 is the same as, and fully synchronized with, cell 2's carrier frequency 504. The result is interference on all three
20 channels.

As described below with respect to Figure 6, it can be seen that by using the same method described above with respect to FDMA systems, the co-channel interference which arises in the conventional TDMA system described in Figure 5 can be similar-
25 ly avoided. This is because the method increases the likelihood that each cell's group of three channels 506 is assigned to a different carrier frequency.

In this exemplary embodiment of the invention, priorities are assigned to TDMA time slots on a given frequency (i.e.,
30 channels) in a manner that reduces the likelihood of co-channel interference. As shown in Figure 6, priorities have been assigned to channels in a TDMA system having three time slots

per frame on a given frequency. Cell 1's priority list 604 causes it to attempt to allocate a pending communication first to channel 1, then to channel 2, and then to channel 3. Cell 2's priority list 606 causes it to attempt to allocate a pending communication first to channel 2, then to channel 3, and then to channel 1. Similarly, Cell 3's priority list 608 causes it to attempt to allocate a pending communication first to channel 3, then to channel 1, and then to channel 2. The direction of the arrow 602 indicates that if a cell is unable to allocate a pending communication to the highest priority channel, it proceeds to the right in the list to find the next available one.

The vertical line 610 shows that if only one conversation is taking place on the same frequency in each cell, the cells' differing channel selection eliminates co-channel interference.

Sometimes in TDMA systems, inaccuracy in the time reference can cause the TDMA structures to slowly slide relative to one another. In other words, there is a time difference between when a first cell recognizes a given time slot, and when a second cell recognizes that same time slot. This situation, referred to as pseudo-synchronization, is depicted in Figure 7, where two cells in a TDMA system are both using the same frequency. There, it can be seen that the second cell's carrier frequency 704 is shifting to the right with respect to the first cell's same carrier frequency 702, causing its group of three channels 708 to similarly shift with respect to the first three channel group 706.

To compensate for this, in accordance with another exemplary embodiment of the invention, a modified method may be applied to the pseudo-synchronized TDMA situation in order to reduce the likelihood of co-channel interference. The priority of channel selection within a given cell is still made as shown

in Figure 6 and described above with respect to fully synchronized TDMA. However, instead of allocating the first channel that is available and suitable, starting from the left side of the list, this exemplary allocation method also compensates
5 for the time difference 710.

Referring to Figure 8, this exemplary method begins at block 801, where a channel is selected that is an integral number of time slots to the right (the rounded off time difference) of the highest ranked channel available in the list. If the
10 result of this addition is a channel number that is within the set of channels assigned to this cell, then the channel is allocated to the pending call and the process ends at block 807.

Otherwise, when the addition of the time difference to the
15 highest ranked channel would result in a channel assignment outside the set of channels assigned to this cell, as determined in block 803, then the channel is instead allocated by subtracting the highest channel number from the channel number determined in block 801. For example, if there are three
20 channels on this carrier frequency assigned to the cell of interest, and the result of processing block 801 is that channel 4 would be assigned, then this would be detected in block 803, and corrected in block 805 so that channel number 1 (i.e., $4 - 3$) would be instead be assigned to the pending
25 call.

Another exemplary embodiment of the invention is shown in Figure 9, which beneficially avoids uneven burnout of hardware (e.g., output amplifiers) within a cell. Such burnout can result from an unchanging frequency priority assignment,
30 because carrier frequencies having a high priority are selected for use much more often than carrier frequencies having a lower priority. As shown in the figure, each cell uniquely prioritized its sequence of available frequencies as

before. However, to avoid uneven burnout of hardware, the priority scheme within each cell can be shifted periodically. For example, one might shift the sequence of each cell by one every night, as shown in Figure 9. The selection order 904 for cell C₁₁ starts out being 1, 2, 3, 4, . . . 20, 21. However, it may be changed overnight, so that the next day the selection order 904' is 2, 3, 4, . . . 20, 21, 1. The other selection orders 906, 908, 910, 912, 914, and 916 may similarly be converted to, respectively, the selection orders 906', 908', 910', 912', 914', and 916'. This shifting operation may continue daily, so that the hardware use will be evenly distributed.

The invention has been described with reference to particular embodiments. However, it will be readily apparent to those skilled in the art that it is possible to embody the invention in specific forms other than those of the preferred embodiments described above. This may be done without departing from the spirit of the invention. The preferred embodiments are merely illustrative and should not be considered restrictive in any way. The scope of the invention is given by the appended claims, rather than the preceding description, and all variations and equivalents which fall within the range of the claims are intended to be embraced therein.

WHAT IS CLAIMED IS:

1. A method of selecting a communication channel for communication in a cellular radio communication system comprising the steps of:
 - 5 providing a channel group having a plurality of different channels to each of a plurality of cells;
establishing, for each of said plurality of cells, a selection sequence which prioritizes said plurality of different channels; and
 - 10 selecting, in one of said plurality of cells, a channel which is currently unused in said one of said plurality of cells having a highest priority as said communication channel.
2. The method of selecting a communication channel of claim 1, wherein said step of establishing further comprises the
 - 15 step of:
designating, for each selection sequence, a set of high priority channels arranged in descending priority order which are different for each of said plurality of cells.
3. The method of selecting a communication channel of claim 2, wherein said step of establishing further comprises the
 - 20 step of:
using a same channel pattern for each of said plurality of cells but starting said selection sequence of each of said plurality of cells at a different channel in the channel
 - 25 pattern.
4. The method of selecting a communication channel of claim 2, wherein said step of establishing further comprises the step of:
 - 30 providing a plurality of lower priority channels in each said selection sequence following said set of high priority channels, said lower priority channels of each cell comprising

channels found in the sets of high priority channels of the other of said plurality of cells.

5. The method of selecting a communication channel of claim 4, wherein said step of establishing further comprises the step of:

grouping each of said plurality of lower priority channels in each said selection sequence according to its respective priority in a set of high priority channels of another cell.

6. The method of selecting a communication channel of claim 1, wherein said step of selecting further comprises the steps of:

determining whether said highest priority unused channel is being used in another of said plurality of cells, and

- if said highest priority unused channel is being used in another of said plurality of cells, then selecting the next highest priority channel which is not currently being used in said one of said plurality of cells and which is not currently being used in another of said plurality of cells.

7. The method of selecting a communication channel of claim 6, wherein said step of selecting further comprises the step of:

- if all channels which are currently unused in said one of said plurality of cells are currently being used in at least one other of said plurality of cells, then selecting a highest priority unused channel which is used only once in another of said plurality of cells.

8. In a cellular communication system having a plurality of co-channel cells, each co-channel cell having a same channel group comprising a plurality of different channels, each channel being usable by the co-channel cell in a communications operation, a method of selecting in a co-channel

cell, from the plurality of different channels, a channel for use in a pending communications operation, comprising the steps of:

in each co-channel cell, forming, from the plurality of
5 different channels, a sequence of channels, such that for each channel in the sequence, a next channel is the same in all co-channel cells;

in each co-channel cell, designating one channel in the sequence of channels to have a highest priority, the designated channel being different in at least two co-channel
10 cells;

in each co-channel cell, assigning progressively lower priorities to remaining channels, by starting with a next channel that follows the designated channel in the sequence of
15 channels, and continuing to assign lower priorities in succession to channels in the sequence until each of the different channels has been assigned a priority; and

in each co-channel cell, selecting a channel for use in the pending communications operation by choosing, from the
20 sequence of channels, an unselected channel having a higher priority than all other unselected channels in the sequence of channels.

9. In a cellular communication system having a plurality of co-channel cells, in which a time difference between co-channel cells is a known number, and wherein each co-channel
25 cell has a same channel group comprising a plurality of different channels, each channel being usable by the co-channel cell in a communications operation, a method of selecting in each co-channel cell, from the plurality of different channels, a channel for use in a pending communications operation, comprising the steps of:

in each co-channel cell, forming, from the plurality of different channels, a sequence of channels, such that for each channel in the sequence, a next channel is the same in all co-channel cells;
35

in each co-channel cell, designating one channel in the sequence of channels to have a highest priority, the designated channel being different in at least two co-channel cells;

- 5 in each co-channel cell, assigning progressively lower priorities to remaining channels, by starting with a next channel that follows the designated channel in the sequence of channels, and continuing to assign lower priorities in succession to channels in the sequence of channels until each
10 of the different channels has been assigned a priority;

in each co-channel cell, identifying, from the sequence of channels, a first unselected channel having a higher priority than all other unselected channels in the sequence of channels or a successor channel;

- 15 in each co-channel cell, selecting for use in the pending communications operation an unselected channel having a priority that is alternatively equal to or less than the priority of the first unselected channel in response to a comparison between the time difference and a predetermined
20 amount of time.

10. A method for reducing co-channel interference in a cellular radio communication system having a plurality of co-channel cells comprising the step of:

- 25 selecting, in a co-channel cell, from a plurality of traffic channels shared by said plurality of co-channel cells, an idle traffic channel which is least in use in the other of said plurality of co-channel cells.

11. The method for reducing co-channel interference of claim 10, wherein said other of said plurality of co-channel cells
30 comprise co-channel cells which are geographically closest to said co-channel cell.

12. The method for reducing co-channel interference of claim 10, further comprising the step of:

determining which of the traffic channels shared by said plurality of co-channel cells is least in use by checking an idle/used status for each of said other of said plurality of co-channel cells.

- 5 13. A method for selecting a traffic channel in a cellular radio communication system comprising the steps of:

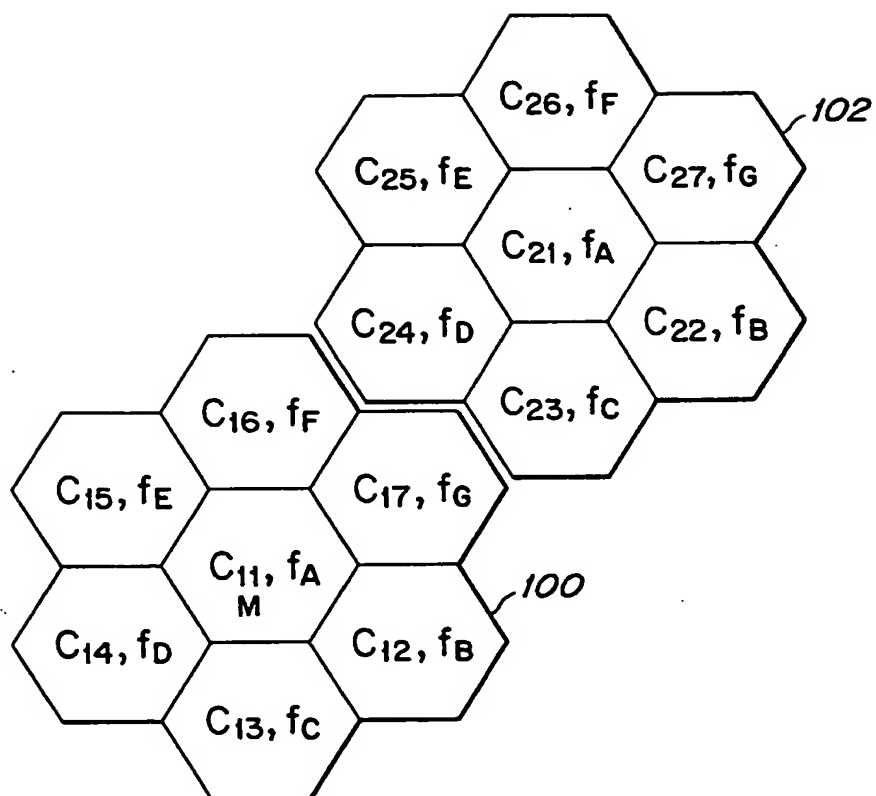
providing a channel group having a plurality of different traffic channels to each of a plurality of co-channel cells;
establishing, for each of said co-channel cells within
10 a group of co-channel cells, a selection sequence of high priority channels which prioritizes selection of a number of said traffic channels such that high priority channels for one co-channel cell differ from high priority channels assigned to selection sequences for said one co-channel cell's nearest
15 co-channel cells; and

selecting, in one of said plurality of co-channel cells, a traffic channel which is currently unused and has a highest priority for selection in said one of said plurality of co-channel cells.

- 20 14. The method for selecting a traffic channel of claim 13, further comprising the step of:

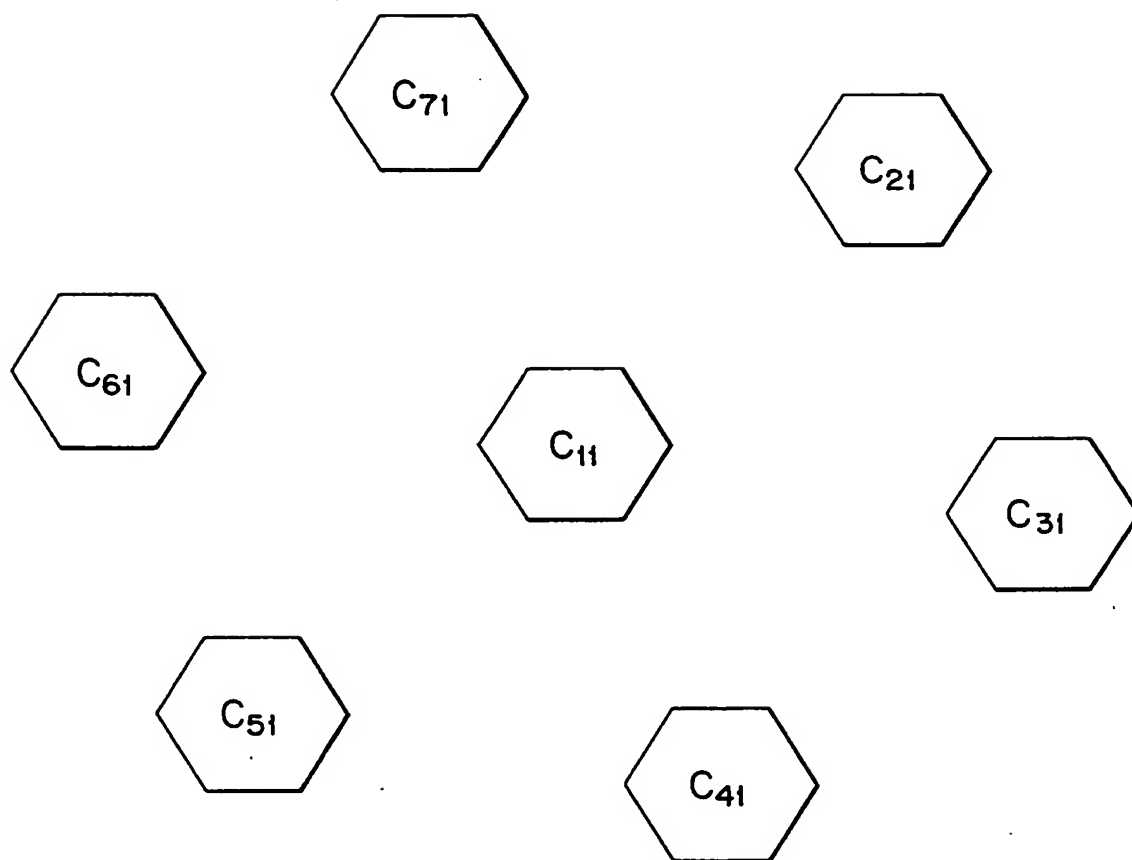
establishing, for each of said co-channel cells within a group of co-channel cells, a selection sequence of lower priority channels which prioritizes selection of a number of
25 traffic channel such that the lower priority traffic channels of said one co-channel cell are used as high priority traffic channels in said one co-channel cell's nearest co-channel cells.

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Fig. 1**SUBSTITUTE SHEET**

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Fig. 2



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C ₁₁ :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	~30
C ₂₁ :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	~30
C ₃₁ :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	~30
C ₄₁ :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	~30
C ₅₁ :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	~30
C ₆₁ :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	~30
C ₇₁ :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	~30

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SUBSTITUTE SHEET

Fig. 3

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402 → 418

C ₁₁ :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	~40
C ₂₁ :	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	1	2	3	~40
C ₃₁ :	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	1	2	3	4	5	6	~40
C ₄₁ :	10	11	12	13	14	15	16	17	18	19	20	21	1	2	3	4	5	6	7	8	9	~41
C ₅₁ :	13	14	15	16	17	18	19	20	21	1	2	3	4	5	6	7	8	9	10	11	12	~41
C ₆₁ :	16	17	18	19	20	21	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	~41
C ₇₁ :	19	20	21	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	~41

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Fig. 4(a)

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C ₁₁	1	2	3	6	9	12	15	18	21	5	8	11	14	17	20	4	7	10	13	16	19	42
C ₂₁	4	5	6	9	12	15	18	21	3	8	11	14	17	20	2	7	10	13	16	19	1	42
C ₃₁	7	8	9	12	15	18	21	3	6	11	14	17	20	2	5	10	13	16	19	1	4	42
C ₄₁	10	11	12	15	18	21	3	6	9	14	17	20	2	5	8	13	16	19	1	4	7	42
C ₅₁	13	14	15	18	21	3	6	9	12	17	20	2	5	8	11	16	19	1	4	7	10	42
C ₆₁	16	17	18	21	3	6	9	12	15	20	2	5	8	11	14	19	1	4	7	10	13	43
C ₇₁	19	20	21	3	6	9	12	15	18	2	5	8	11	14	17	1	4	7	10	13	16	43

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Fig. 4(b)

Fig. 5^{6/8}

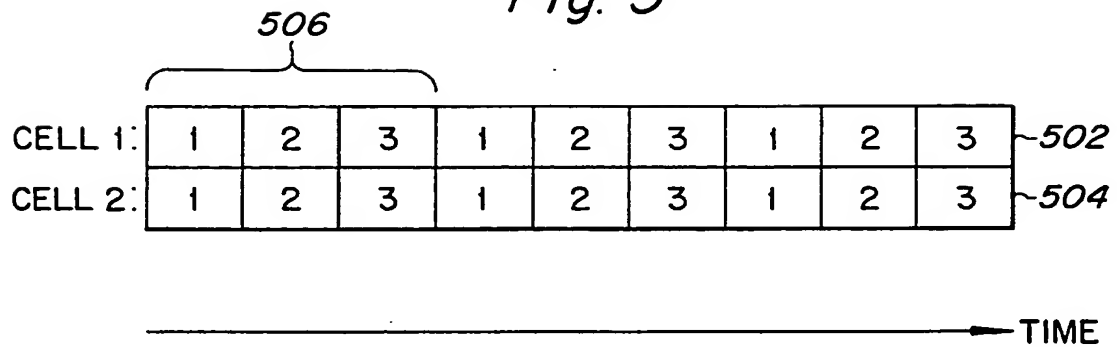


Fig. 6

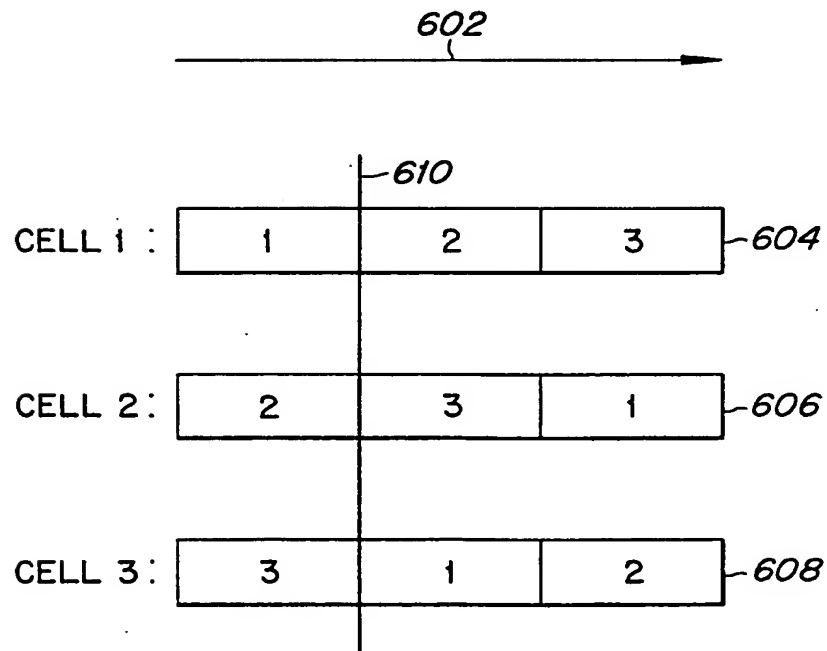
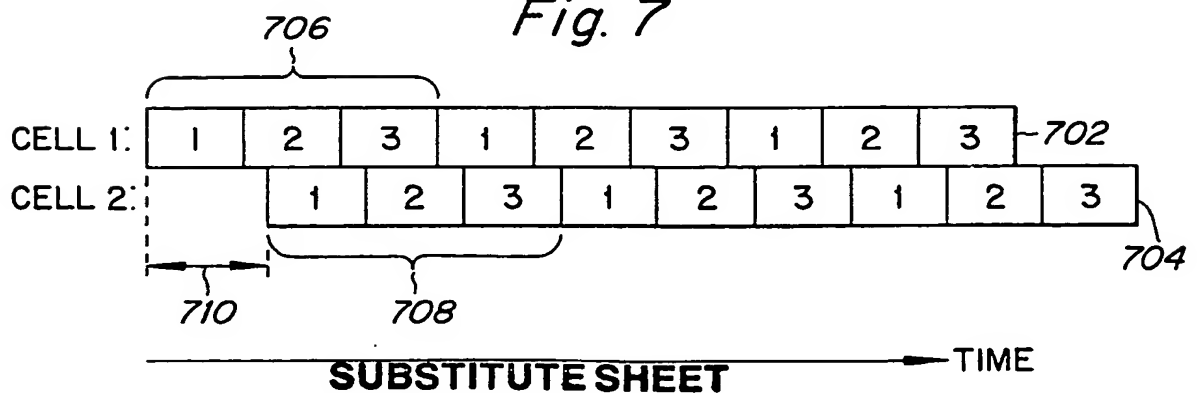


Fig. 7



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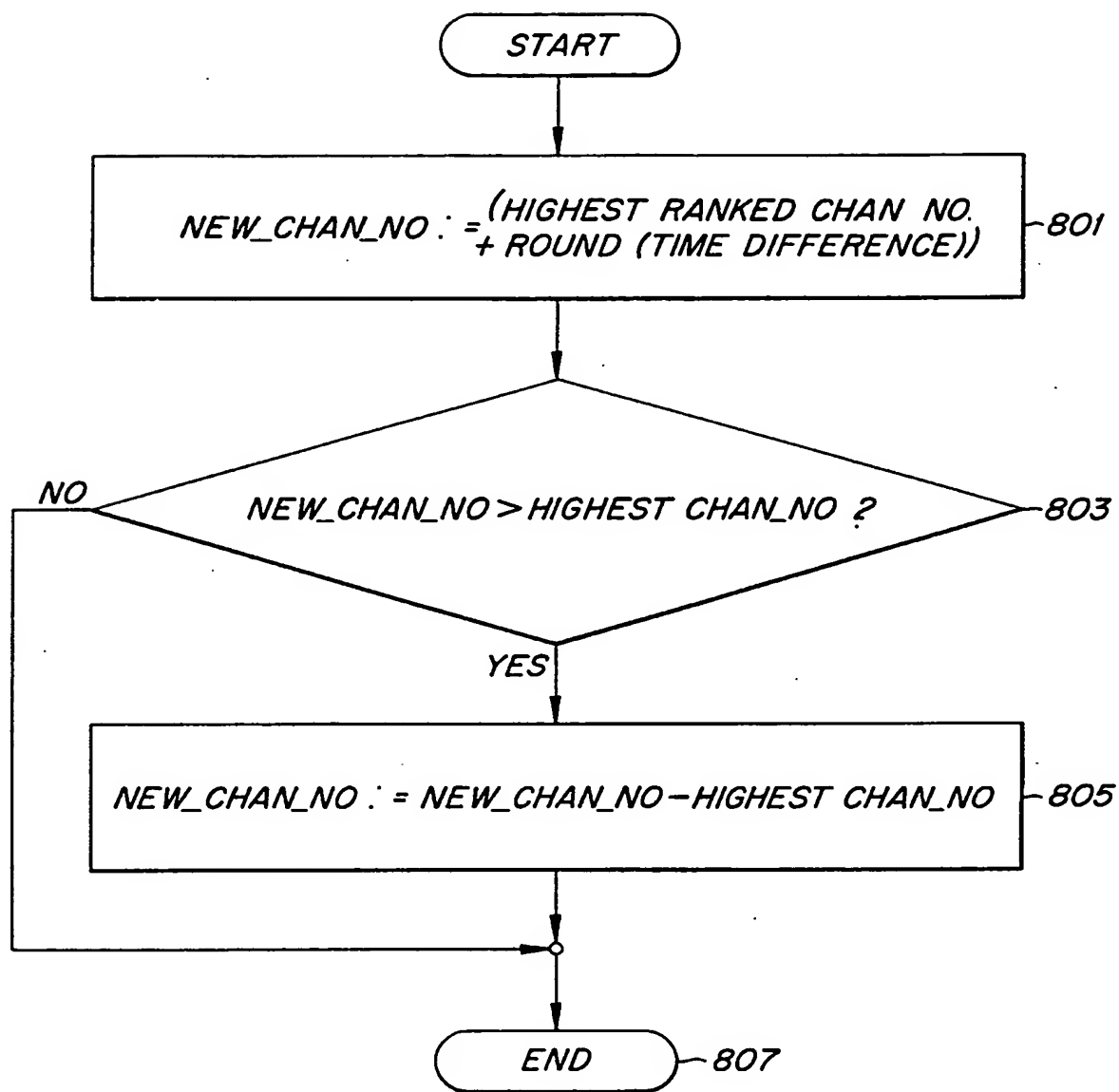


Fig. 8

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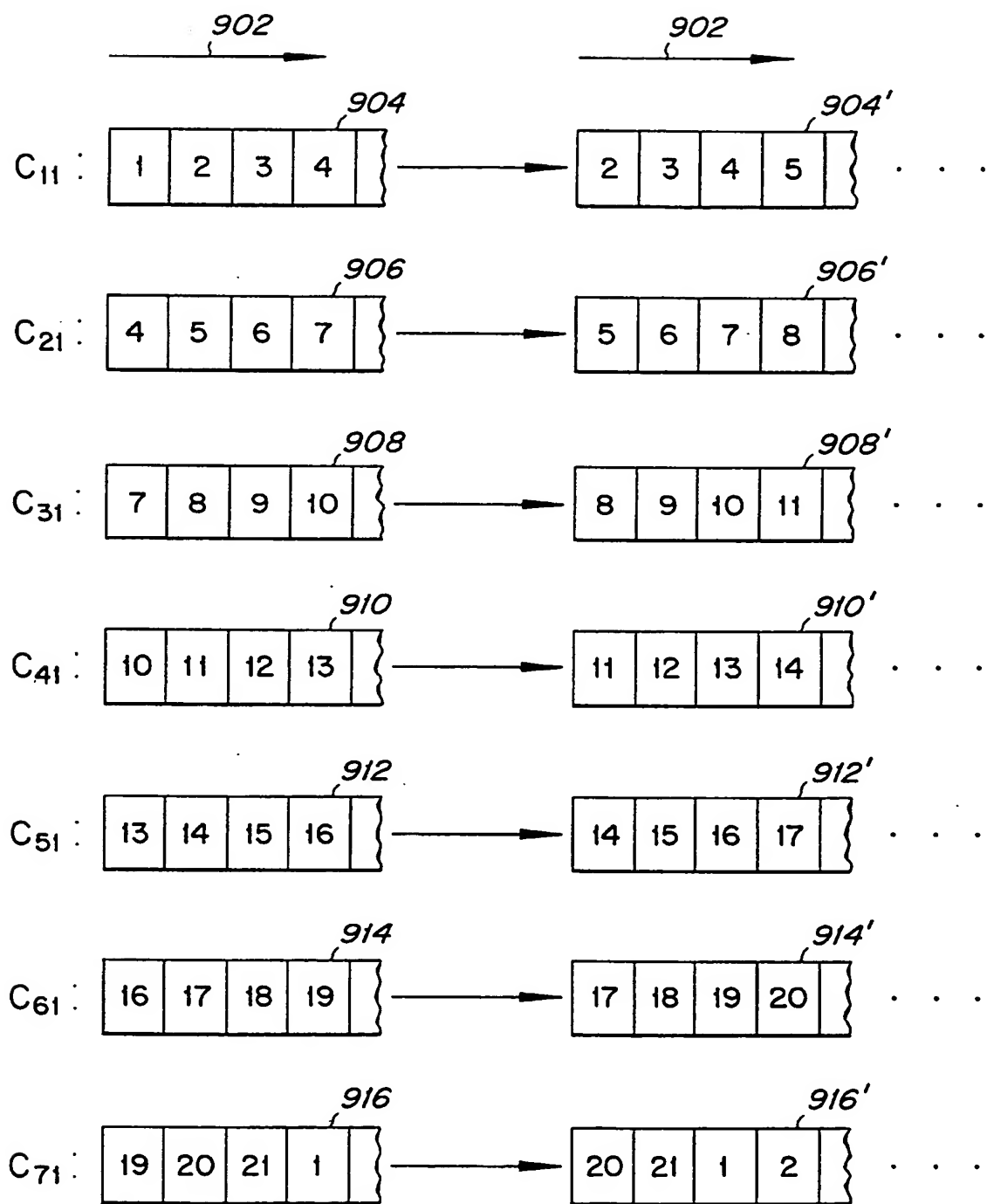


Fig. 9

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 94/00795

A. CLASSIFICATION OF SUBJECT MATTER		
IPC6: H04Q 7/38 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC6: H04Q		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE,DK,FI,NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP, A2, 0441372 (NEC CORPORATION), 14 August 1991 (14.08.91), column 6, line 8 - line 57	1-5,8,13,14
Y	--	6,7,10-12
Y	EP, A2, 0202485 (NEC CORPORATION), 26 November 1986 (26.11.86), page 7, line 17 - page 8, line 4; page 13, line 18 - page 14, line 6	6,7,10-12
A	GB, A, 2249922 (MATSUSHITA ELECTRIC INDUSTRIAL CO. LTD.), 20 May 1992 (20.05.92), page 10, line 23 - page 11, line 25	9
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
30 December 1994		02-01-1995
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86		Authorized officer Bengt Jonsson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 94/00795

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP, A2, 0466139 (KABUSHIKI KAISHA TOSHIBA), 15 January 1992 (15.01.92), page 12, line 7 - line 11, abstract -- -----	9

INTERNATIONAL SEARCH REPORT
Information on patent family members

26/11/94

International application No.
PCT/SE 94/00795

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		AU-A- 7091691	15/08/91
		CA-C- 2035963	20/09/94
		JP-A- 3234130	18/10/91
		US-A- 5263176	16/11/93
		JP-A- 3234131	18/10/91
EP-A2- 0202485	26/11/86	SE-T3- 0202485	
		DE-D, T- 3689290	28/04/94
		JP-B- 6059039	03/08/94
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		US-A- 4747101	24/05/88
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		JP-A- 62085525	20/04/87
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